The sarcocarp is very pleasant to the taste, and is to be compared very closely with the exterior of many species of the genus Pyrus—as far as I could judge from the single specimen brought home in the green state.

Abundant fresh seeds deprived of the sarcocarp were procured, and a dissection of these shows how accurate are the drawings of Crueger, which were produced in Dr. Morris's article. We hope to secure full sets of herbarium specimens later.

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The Rotation-Period of Venus.

During the years 1876 and 1878 I paid some attention to Venus at the Kempshot Observatory, and although no distinct markings on the disc were seen in the very small equatorial, yet the following observation may prove valuable:—"1876 October 2, 6 a.m. The planet dichotomised, but the terminator is not straight; the S. horn projects, and the N. horn is rounded off."

By comparing the sketch then made with the drawing, Fig. 1, in the article in Nature of February 20 (p. 367), there can be no doubt that the broader features in the curvature of the terminator are the same in both. Fig. 1 was taken from a drawing by Signor Mascari, October 12, 1892, or about sixteen years after mine.

Now every eight years the earth and Venus come to nearly their same position again in their respective orbits, for 365·24d. × 8 = 2921·9d., and 224·7d. × 13 = 2921·1d.; and consequently if the rotation-period of Venus be 224·7d., any well-marked permanent feature will become visible every eight years.

The question is whether this curvature of the terminator will prove to be a permanent feature or not under the circumstances detailed above; and for the answer we shall have to wait until the western elongation of Venus in September or October 1900, when observations made at or a little after the time of dichotomisation will show whether the agreement of the drawings in October 1876 and 1892 was a mere coincidence or not.

Jamaica, March 14. Maxwell Hall.

A Remarkable Meteor.

Mr. Backhouse's observation of the beginning of flight of the slow-moving meteor of March 1 appears to have been from a point 2° south-east of α Canis Minoris instead of between α and β of that constellation, as I at first assumed from the description. This misunderstanding shows the extreme importance of noting meteor tracks according to the best method, viz. that of giving the R.A. and Decl. of the beginning and end points. This is at once simple and effective; it avoids the frequent errors which occur when projecting meteor tracks from descriptions (sometimes ambiguous) of their courses by the stars, and saves endless trouble.

A reinvestigation of the path of the meteor shows it to have commenced its visible career when nearly over York at a height of 55 miles, and it was last seen by the observer at Sunderland when 53 miles high. Mr. Clark at York, however, watched it much further, and after it had passed over Heligoland when its height had again increased to 55 miles. The radiant was nearly on the western horizon, and the meteor, which in the early part of its flight was descending towards the earth, showed a slight ascent towards the end. The average velocity from the two estimates of duration seems to have been about 20 miles per second.

An observation from Kiel or Hamburg would be very useful for comparison, as the meteor at its terminal stages was comparatively near those places, and must have been far more brilliant than it appeared from York and Sunderland.

Bristol, April 3. W. F. Denning.

Simple Huyghens' Apparatus for the Optical Lantern.

In his excellent handbook on experimental optics, "Light," Mr. Lewis Wright describes and figures the well-known double-image phenomena to be observed when an ink-dot is viewed through two superposed rhombs of calc-spar. He does not suggest, and I have not seen elsewhere the suggestion, that the experiment is readily adapted to lantern projection. This, however, is the case, and when so projected this experiment is more useful to the demonstrator than that of the double-image prisms, commonly known as Huyghens' experiment, since the apparatus is more simple. There is no colour correction to explain—nothing to occupy the mind of the student but the action of the spar.

My method is to take two small rhombs of a thickness of 1½ inches or more, and mount them near together in such a way that one or both can be rotated. I use by preference a small parallel beam from the parallelising lens, and between this lens and the rhombs, close to the latter, is placed a thin metal plate having an aperture of a size depending on the thickness of the rhombs. The thicker the rhombs the larger, of course, can be the aperture. The rays, after passing through the pieces of spar, are focused by the ordinary objective so as to give sharp images of the aperture in the plate. Rhombs can often be found whose cleavage faces are quite perfect enough to allow sharp images.

It is evident that a single rhomb in the position here indicated may be made to serve nearly or quite all of the purposes of the double-image prism—may sometimes, indeed, to the advantage of the demonstration, replace the analysing Nicol. This fact has its obvious usefulness in the present scarcity of Iceland spar.

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THE MANAGEMENT AND PROTECTION OF FORESTS.[1]

II.

The working plan of coppice woods is a simple matter. The area is divided into as many compartments as there are years in the rotation. If the coppice is cut, when it has attained the age of fifteen years, fifteen compartments are formed, and every year the old wood on one compartment is cut, after which the coppice shoots grow up to form the new crop. The rotation is determined by the species composing the coppice, and the class of material required, and the yield depends upon the areas cut over, which are equal, where the quality of the locality is uniform, unequal in inverse proportion to the quality, where the quality varies.

In the case of high forests, matters are more complicate, and a brief indication of the main subjects that must be attended to, may serve to explain what is done. A thorough examination of all portions of the forest, its previous treatment, soil, climate, and other conditions, which influence the growth of trees, an accurate and detailed survey of the growing stock, and, lastly, the market for timber and other produce, and the labour available for forest work, are the points which must be examined in the first instance. The next subject is the study of the lines of communication, roads, and watercourses to be used for the transport of timber; and, lastly, the subdivision of the forest into blocks and compartments. A forest to be manageable must consist of compartments of moderate and fairly uniform size. On level ground regular rectangular figures are most convenient; in a hilly country, compartment boundaries must follow the configuration of the ground. Obviously it is in every respect convenient that, wherever practicable, compartment boundaries should coincide with export roads; the sooner, therefore, a system of roads is projected and traced on the ground the better, the traces serving as compartment lines, though the roads need not be built until cuttings are made in the compartments adjoining them.

Simultaneously with the division of the forest into blocks and compartments, the method of treatment must be considered, the choice of species, and the sylvicultural system, particularly with regard to the regeneration of the forest, and the arrangement of cuttings. Large forest areas will generally have to be divided into several working sections, each with its own system of treatment—say one working section for coppice woods, another for coppice under standards, a third for high forest of spruce or Scotch pine, worked on short rotations, with clear cutting and planting; others, again, for high forest worked on a long rotation, under the selection and shelter-wood compartment systems.

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[1] "A Manual of Forestry," by William Schlich, C.I.E., Ph.D. Vol. iii. (pp. xix + 397). "Forest Management," by William Schlich. Vol. iv. (pp. xix + 593). "Forest Protection," by W. R. Fisher, B.A. (London: Bradbury, Agnew, and Co., 1895.) (Continued from p. 515.)

Two prominent points to be settled in a working plan are to determine the rotation and the annual yield. As regards the rotation—that is, the age at which the timber should be cut—the requirements of the market must be consulted in the first instance. It has already been mentioned, that where pit-props find a ready market, coniferous woods may profitably be grown on a short rotation of 50 to 70 years. Where building wood of moderate dimensions pays best, a rotation of from 80 to 100 years will be more profitable. Oak timber, on the other hand, takes a long time to attain a marketable size, and afterwards, with advancing age and increasing diameter, continues long to increase in value. Where it is intended to regenerate forests by self-sown seedlings, trees must of course be allowed to attain that age at which they bear good seed in sufficient quantity; nor must they be allowed to remain after the production of good seed has diminished.

These considerations follow as a matter of course. A more difficult question is, within these limits, to decide upon the most suitable rotation. It might be thought that the simplest plan would be to divide the total income expected during the rotation, less the expenses incurred, by the number of years in the rotation, and to select that which gives the largest mean annual net income. Adopting the data given on page 513, which represent the growth of a Scotch pine forest on land of middling quality, the mean annual net income under a rotation of 80 and 100 years would be as follows:—

$$\frac{2225 + 4 + 36 + 67 + 86 + 91 - (60 + 3 \times 80)}{80} = 27{\cdot}61 \text{ shillings.}$$

$$\frac{3376 + 4 + 36 + 67 + 86 + 91 + 95 + 94 - (60 + 3 \times 100)}{100} = 34{\cdot}89 \text{ ,,}$$

Under this mode of calculation, which takes no account of interest, the mean annual net income increases with the length of rotation, and this increase continues until volume- and value-increment become so much reduced that they will no longer cover the increased outlay. This result, however, does not agree with what has previously been explained. If, as ought to be done, interest is taken into account, a rotation of 80 years is that which, in the case here assumed, yields the highest net rental, and is hence financially the most profitable.

The rotation to be adopted is, it may readily be imagined, a fertile subject of controversy, which often gives rise to animated discussions among foresters in Germany. The author is in favour of what is commonly called the financial rotation, under which the forest capital (soil and growing stock) yields the highest interest, and under which, as explained above, the soil expectation value and net soil rental culminate. But Dr. Schlich justly observes that purely financial interests must in many cases be modified by considerations of a different character.

How the annual yield, that is the timber which may be cut annually or within certain periods, is determined in the case of coppice woods, has already been indicated. In the case of high forest, three different systems are generally followed. The first of these the author designates as the allotment of woods to the different periods of a rotation. A rotation of 80 years is divided into four periods of 20 years each. It will serve to make matters clear, if we assume the existence of a normal forest with an even distribution of age classes. To the first period would be assigned in such a forest all woods between 61 and 80 years, to the second those between 41 and 60 years, and so on, so that the fourth class would comprise the youngest woods under 20 years. Such a regular forest, however, does not exist, and what in reality is done, is to assign the oldest woods to the first period, and to distribute the others according to their age, as well as can be done. A number of compartments, stocked with old timber, are thus assigned to the first period, and care is taken to allot to each period approximately equal areas, which, if there are great differences in the quality of the locality, are reduced to a common standard. The woods placed in the first period are then measured, their volume calculated, and the increment for half the number of years in the period is added. The total volume divided by 20 gives the mean annual yield during the first period. The cuttings in the woods assigned to each period are arranged so as to suit sylvicultural requirements and economic considerations. The allotment of compartments to periods can obviously be made by volume instead of by area. In that case old woods are measured, and the proper increment added. For younger woods the volume, which will stand on the ground at the time of cutting, is calculated from yield tables. Equal volumes are assigned to each period, the oldest woods being allotted to the first, and the youngest to the last period. The compartments allotted to one period, whether by volume or by area, will not necessarily be contiguous; they will often be scattered over the whole forest. Whether the allotment to periods is regulated by area or by volume, a framework must be constructed, showing during which period each wood is to be cut. Hence this system is commonly known as the framework system. However irregular the forest may have been; at the end of the rotation its condition will approximate to the normal state. Thus the system introduces order, and is yet elastic, leaving sufficient latitude in the location of cuttings during each period.

The second system regulates the yield according to increment and growing stock. The legitimate yield of a forest during a given period in the first instance depends upon the quantity of timber produced during that period. During one year more should not, as a rule, be cut than the quantity represented by the sum total of the annual increment laid on in all portions of the forest. In a normal forest, with a regular succession of age classes, the legitimate annual yield is equal to the annual increment. In a forest, however, which, though well stocked, only contains the younger age classes, the produce of which is not marketable, no yield is possible, though the annual increment may be considerable. Again, in a forest where the older age classes preponderate, it is not only permissible, but it is in most cases necessary, to cut considerably more than the total annual increment. This principle has long been recognised, and as early as 1788 the management of the Austrian State forests was based upon it. When the older age classes preponderate, it is proper to fix a period, during which the surplus old growing stock shall be removed. If this period is called a, and I the actual annual increment, then the legitimate annual yield of the forest is

$$= \mathrm{I} + \frac{\text{actual growing stock} - \text{normal growing stock}}{a}$$

This, which is known as the Austrian assessment formula, is still used in many public and private forests of Austria and Germany. Space forbids further discussion of this and similar methods. Suffice it to say that under this system no framework is needed, and that on this principle it is best to determine the yield for a short period only. Hence in those forests, where this system has been adopted, the yield is generally determined for ten years, and at the expiration of this time a new working plan is made.

The third system, which is in force in the State forests of Saxony, was originated by Cotta in 1811, and has been brought to its present state of perfection by Judeich, for many years until his death in 1894, Director of the Tharand Forest School, one of the ablest foresters of Germany. Its leading idea is to treat each wood, or each compartment, or each group of compartments, on its merits, the management of the whole forest representing a summing-up of the treatment laid down for each wood. It has already been stated that a large portion of the State forests in the kingdom of Saxony are nearly pure spruce forests, managed on a very simple system by clear cutting and planting, and that most of them are worked on a rotation of 80 years. At first sight elaborate working plans might seem to be superfluous under these circumstances; it might be thought sufficient if a suitable area of the oldest woods were cleared and planted annually. However, had the forests been worked in this manner, without safeguards against storms and insects, their condition would not be what it actually is, nor would the financial results be so satisfactory. Pure spruce woods are apt to be blown down. Spruce plantations are apt to be destroyed by the pine weevil, and it was to a great extent the necessity for guarding against damages from these causes which led to the development of the present system in Saxony. On the spurs and in the valleys of the Erzgebirge and the other mountainous regions of Saxony, where most of the State forests are, the direction of the prevailing winds, though generally westerly, is greatly modified by the configuration of the ground. Accordingly the cutting series, in which all clearances proceed against the wind, must be most skilfully arranged, so as to guard against damage. Again, in order to guard against the ravages of insects, the principle of breaks in the successive clearances has been consistently carried out. When in one spot a cutting has been made, the adjoining area is not cleared until the young wood on the first area has become completely established. The result consists in numerous cutting series, separated by severance cuttings, and numerous clearances of limited extent. An essential feature in this, as in the second system, is that the yield is determined only for a period of 10 years. The woods proposed for cutting during that period are carefully examined. According to Judeich's plan, the question whether a wood should be cleared is determined by purely financial considerations. Dr Schlich, however, very properly urges that other considerations also should have due weight. Obviously a regulator is necessary, to prevent too large an area being assigned to one period. This regulator is obtained in a very simple manner. The total area is divided by the rotation. For a forest of 2400 acres, worked under a rotation of 80 years, 300 acres would be the area cleared during a period of 10 years.

The system here sketched is simple and effective, but, like all systems, the results depend upon the manner in which it is worked. The young woods must be complete and vigorous, and though the outlay in forming them, is multiplied seven-fold in 80 years under the operation of compound interest, even at the low rate of 2½ per cent., undue economy in this first operation, and in the subsequent tending of the woods, would result in waste and diminished net revenue from these magnificent estates.

Thus far the management of forests has been discussed, as if timber were the only legitimate forest produce. This, however, by no means is the case. Large plantations have been made in Assam by the Forest Department, ever since 1870, of *Ficus elastica* for the production of india-rubber. Myrobalans, the fruit chiefly of *Terminalia chebula*, is an important article of forest produce in Western and Central India. The Scotch pine forests which surround the old town of Nürnberg, are important, less on account of the timber which they produce, than because the annual fall of needles furnishes litter to the peasants in the vicinity, who chiefly depend upon the growth of vegetables, and who use the dry needles as a substitute for the straw which they do not produce. In the drier regions of India, a commencement was made in 1874 to protect woodlands for the specific purpose of furnishing cattle fodder in times of drought. Had these attempts been carried on with sufficient vigour and perseverance, they might have contributed largely to mitigate the sufferings of the agricultural population during seasons of deficient rainfall, which in most parts of the Indian Empire occur from time to time.

Other articles of produce obviously demand other systems of management. With these, however, forest proprietors in the United Kingdom at present have no concern. Their interest is to produce timber of the best description, and to sell sufficient quantities to attract purchasers at regular intervals. A beginning can only be made by actual experience. Should any proprietor have the courage and foresight to ask the author of the manual here reviewed, or any other really competent and experienced forester, to take in hand his forest estates, and to organise their management on a well-considered plan, the result would certainly induce others to follow suit. In a matter of this kind, example is better than teaching, and the sooner a commencement is made, the better for the landed interest of Great Britain. Patience, however, and plodding perseverance, are indispensable conditions of success in forestry. Timber takes many years to attain marketable size, its growth in volume and value is slow, and the money returns are moderate. These are the chief reasons why systematic forestry is not yet respected in Great Britain. In this, as in other matters, the pressing needs of the moment stand in the way of undertakings which would, slowly but surely, advance the future welfare of the country.

THE PROTECTION OF FORESTS.

We now pass to the consideration of that branch of forestry which deals with injurious external influences, and with the measures that may be adopted to guard against them. These matters form the subject of Mr. Fisher's volume. In the introduction a brief account is given of the earliest attempts at forest protection, sacred groves, and game preserves. Sacred groves are found in many parts of India. In the moister regions, where forests are abundant, we find them, as Mr. Fisher correctly observes, in the hills south of the Brahmaputra river, but also in other districts; for instance, upon the Javadies and other hill ranges of South India. In the regions with a dry climate, as in Rajputana, the sacred groves of *Anogeissus pendula* are an ornament of the country, and have often proved a boon to the people by providing cattle fodder in seasons of drought. Old game preserves have in many instances been transformed into useful forests. The forests of Babul, *Acacia arabica*, on both sides of the Indus River, were originally formed and maintained as the game preserves of the Ameers of Sind, and are now of considerable importance in that dry and otherwise forestless country.

Part i. is devoted to the protection of forests against man. The destruction of forests through other agencies is insignificant, compared to that accomplished by the improvident cupidity and careless ignorance of man. These tendencies of mankind the entire manual is intended to counteract, in so far as it teaches how forests should be maintained and managed. The present volume only deals with special matters in this respect, the protection of forests against encroachment, damage, misappropriation, irregular and excessive exercise of rights of user.

Part ii. deals with protection against animals. Here the chapters relating to insects are the most important. The damage done to forests by caterpillars and beetles must be seen in order to be believed. The Nun Moth (*Liparis monacha*) has for several centuries been known as one of the most formidable enemies of spruce forests in Germany, Austria, and Russia. It is also very injurious to the Scotch pine, and likewise feeds upon the leaves of the beech and other broad-leaved trees. From 1888 to 1891 this caterpillar appeared in such enormous numbers in the spruce woods of South Germany, particularly of Bavaria, that over large areas the trees became entirely denuded of their leaves, and were killed. In the Ebersberg Park, a densely stocked forest, spruce with a small proportion of beech and Scotch pine, forming a compact area of 16,510 acres, 4700 acres were completely bare, while on 7400 acres the trees were severely damaged. The timber that had to be cut on this area, in consequence, amounted to 53,000,000 cubic feet, more than half the normal annual yield of the State forests in the kingdom of Bavaria. Timber-cutters were brought from all parts of the country, and lodged in temporary barracks built in the forest. A railway seven miles long was constructed into the heart of the devastated area; tramways were laid upon the rides separating the compartments, and portable lines were used to bring out the logs. At the same time the Nun had devastated other extensive areas in Bavaria and the adjoining districts of Württemberg, necessitating the cutting of large quantities of timber. The news of these events created great uneasiness among timber traders, and a disastrous fall in timber prices was anticipated. This, however, was to a great extent guarded against by the prompt and carefully-planned measures taken by the Bavarian Government. The annual cuttings in the Bavarian State forests were at once considerably reduced, and the action thus taken was aided by the circumstance, that the timber of the Ebersberg Park has a very good name, and justly so, for the stems are well-shaped, clean, without knots, and the wood is even-grained. Most of the large timber was sent across the Alps by the Brenner line, and found a ready market in Italy. The smaller pieces were sold to paper factories to be converted into wood pulp, and what was only fit for fuel was collected at the great depôt that supplies the town of Munich with firewood. The cleared areas have since been planted up, and except that the working plan of the forest was completely upset, no permanent damage was done by the calamity.

If the timber of Conifers killed by caterpillars is not cut at once, it is apt to be much injured by bark beetles. In the present instance this was avoided; but formerly, with the means of communications less developed, and the plan of action less prompt and less comprehensive, the ravages of *Tomicus typographus* and other bark beetles have greatly intensified the mischief. In North Germany and in Russia the principal devastations by the Nun, and by the bark beetles in its wake, have been recorded in 1688 (Altmark), 1794 to 1797 (Southern Thuringia), 1837 to 1840 (the greater part of Germany, from the North German Plain to the lake of Constance), 1845 to 1867 (Western Russia and Eastern Prussia, extending over forest areas aggregating 32,000 English square miles).

The moth lays about 150 eggs, and, as is the case with other species (for instance, *Orgyia antiqua*), the male and female insects of one brood attain the perfect stage on different dates, necessitating the inter-breeding of different broods, and thus insuring a vigorous development of the pest. A succession of warm dry springs, with weather otherwise favourable to the life of the insect, brings about the rapid multiplication of the Nun, and, unfortunately, the protective measures are difficult, and their success uncertain.

Fortunately, the Nun has formidable enemies. A number of birds eat the eggs—up to 200,000 eggs have been found on one tree; but only the starling eats the hairy caterpillars on a large scale. Of insects, parasitic *Diptera* (*Tachinidæ*) are exceedingly useful in destroying the caterpillar wholesale. The most powerful ally of the forester, however, has in most cases been an epidemic disease, which breaks out among the caterpillars when the multiplication has attained its climax. They congregate in large masses at the tops of trees and branches, where they die without making any attempt at feeding. In the diseased caterpillars several species of bacteria have been found in large numbers; attempts have also been made to inoculate healthy caterpillars with these bacteria; the success, however, has not been sufficient for practical purposes.

Equally mischievous, not, however, in spruce woods, but in those of the Scotch pine, is the Pine Moth (*Gastropacha Pini*), a species, Mr. Fisher states, not found in Great Britain. Formerly the Pine Moth was dreaded as the greatest enemy of the extensive pine forests of Northern and Middle Germany. Fortunately, however, when its life-history became better known, a simple and most effective remedy was devised. The eggs are laid early in August; the caterpillars, which come out about the end of that month, proceed at once to feed on the needles; but, being small, the damage done at this season is not considerable. When night frosts commence, they descend from the trees, and spend the winter months ensconced in moss or dry needles near the foot of the stem. In spring, aroused by the warmth, they ascend the trees and eat them bare in no time. The average consumption by one caterpillar is estimated at 1000 needles. What is done by way of protection against this pest, is to prevent their ascending the trees in spring, and this is effected by putting broad bands of tar, grease and glue, mixed, round the stems, the outer rough bark having first been scraped off to present a smooth surface. These sticky bands the caterpillar cannot get over, and in this manner nearly the whole of the pine forests in the plains and broader valleys of Germany are now protected against the ravages of this insect. The pine woods on the hills, having generally a mixture of other trees, are safe from the attacks of the Pine Moth.

The Scotch pine has many enemies besides the Pine Moth. During the summer of 1895 the Pine Noctua (*Noctua piniperda*) and the Pine Looper Moth (*Geometra piniaria*) have appeared in immense numbers, the former between Darmstadt and the Main River, and the latter in the forests near Nuremberg, as well as in the Rhine Valley.

Among insects which attack young plants, the Pine Weevil (*Hylobius abietis*) is one of the most mischievous. The larva does not do much damage, but the beetle is found in large numbers in plantations of spruce and Scotch pine up to six years of age, killing the plants by gnawing the bark all round the stem, down to the root. It lays its eggs on stumps and roots, and the best protection is to give him as little opportunity as possible for breeding in the vicinity of young plantations. Small felling areas and intermittent fellings ought to be the rule; when a clearance has been made, the adjoining area should not be cut until after the lapse of three to five years.

Of the Cockchafer (*Melolontha vulgaris*) the beetle does some damage by eating the foliage of broad-leaved trees, particularly of the oak; but the chief mischief is done by the larva, which eats the roots of plants. A fungus (*Botrytis tenella*) some years ago in France was found to infest the larvæ, and at one time it was hoped that it might be possible, by inoculating larvæ with the spores, to spread the infection, and thus to destroy a large portion of the brood. Experiments have been made with great care in France, in Switzerland, and at Berlin, but hitherto without practical success.

Part iii. discusses protection against plants, forest weeds, climbers, parasitic and epiphytic phanerogams and fungi. In tropical and sub-tropical forests huge woody climbers play an important part, and are often very mischievous. They bend and twist the trees on which they have found their support, and finally, by their dense luxuriant foliage, smother them. Several species of epiphytic ficus enclose the stem of teak or other useful trees by a network of aërial roots. The extirpation of climbers and epiphytes forms an important part of a forester's duty in India. Our North Europe climbers, the honeysuckle and *Clematis Vitalba*, are innocent representatives of those gigantic enemies of the forester in warmer countries.

Green parasites, such as *Viscum* and *Loranthus*, probably in a manner contribute their share towards the nourishment of the tree upon which they have established themselves, and some botanists have even gone so far in their appreciation of this symbiotic arrangement, as to claim for the mistletoe the gratitude of the apple-tree, upon which it lives. Be that as it may, in the Southern Schwarzwald, chiefly at lower elevations, *Viscum album* to such an extent infests the Silver Fir that many trees are killed, and that much of the timber is rendered useless by the haustoria of the parasite. And on the Nilgiris of South India several species of *Loranthus* have attacked the plantations made on those hills of the Australian *Acacia melanoxylon*, killing a large number of trees.

The damage done to trees by fungi has of late years justly attracted much attention. *Phytophthora omnivora*, de Bary, closely allied to the potato pest ((*P. infestans*) attacks the seedlings of the beech and other broad-leaved trees, and destroys them wholesale in May and June, especially if protracted wet weather sets in.

Æcidium elatinum, Link, is the fungus which infests the Silver Fir, manifesting itself in two different ways—by an abnormal hypertrophy of the branches, known as witches' brooms, and by canker or diseased swellings of the stem. The trees attacked with canker are worthless for timber, and the damage is very considerable. Nothing, however, can be done in the matter, save to destroy the branches bearing witches' brooms, and to cut out all trees attacked by canker. Fortunately, the system of management which suits the Silver Fir best, selection fellings, or gradual cuttings under shelter woods, permits the removal of canker trees.

The dreaded Larch disease is chiefly caused by a fungus (*Peziza Willkommii*, R. Hartig). Wounds made by the Larch Miner Moth, *Tinea* (*Coleophora*) *Laricella*, facilitate the entry of the spores into the tissue.

Broadly speaking, the most effective protection against the ravages of insects and fungi is a correct system of management. One important result, arrived at by long experience, in this respect, is that all other circumstances being the same, mixed woods are less exposed to such ravages than pure woods, consisting of one species only. Short-lived plants, such as our field crops, are exposed likewise to damage by insects or fungi; but, in the case of trees and shrubs, the damage is intensified, because they furnish food and other circumstances favourable for the multiplication of the pest, not during one season only, but continuously. This has been our experience hitherto, in the case of forests, as well as in the case of plantations of coffee, tea, cinchona, or other woody plants. The vineyards of Europe are a case in point. *Oidium Tuckeri*, Berk., commenced its ravages in South Europe in 1851, nearly destroyed the vineyards of Madeira, and probably was the fungus which, in 1856, put an end to the cultivation of the grape in the valley of Kunawar in the North West Himalaya. During the last ten years, two pests, a fungus and an insect, both introduced from North America, have done enormous damage—*Peronospora viticola*, de Bary, and the dreaded *Phylloxera vastatrix*, Planch. The coffee plantations of Ceylon have been annihilated between 1869 and 1880 by that terrible fungus *Hemileia vastatrix*, Berk. In Java, where this fungus has also made its appearance, without, however, doing much damage, other trees are invariably planted with the coffee, and this to a certain extent is also done in the coffee plantations of Coorg and the Wynād. In the extensive and magnificent tea plantations, which now cover the Assam valley, it formerly was the custom to preserve belts of the original forest on broken ground and along ravines, and the experience of foresters in Europe points to this plan as an important safeguard against the spread of fungus and insect pests. Among foresters in Germany and in other countries on the continent of Europe, the conviction has now generally gained ground, that every effort must be made to maintain mixed woods, consisting of several species, where they exist, and in pure forests to introduce a mixture of other species, wherever such is practicable. The object is to make the conditions for the multiplication and spread of insects and fungi less favourable than they are in pure forests, consisting of one species only.

The forester, unfortunately, has to contend with other enemies besides man, animals, climbing plants and fungi. The heat of the sun, drought, frost, snow and ice, storms and fires, smoke and acid fumes of factories and furnaces are destructive to an extraordinary degree, and often entirely upset his plans of operations. And in addition to all this, some species are subject to endemic widely-spread disease, such as the needle-shedding of young Scotch Pine plants, the cause of which has not yet been ascertained. All these matters are dealt with in the concluding parts of Mr. Fisher's book.

The recollection of the storms which blew down enormous masses of timber in Scotland in 1893 and 1894, ought to invest this portion of the book with special interest. Here again a correct system of management affords the best protection. Cutting series of moderate extent, adapted to the configuration of the ground and to the locally prevailing wind direction, severance cuttings timely made—these are the principal measures by which the extensive pure spruce forests of Saxony and Thuringia have, it is true, not been absolutely protected against storms, but protected so far, as such is possible in pure forests consisting of a shallow-rooted species that is easily blown down.

Protection against fire is not a matter of great practical importance in the moist climate of Great Britain. Mr. Fisher has, nevertheless, very properly treated it somewhat fully, and has also alluded to the work of fire protection in India. The peculiar feature of the climate in most provinces of India is the long dry season, at the end of which grass, leaves, herbs, are as dry as tinder. The natural results are the annual jungle fires of the hot season, an institution as old as the civilisation of the country. To the annual fires it is due that fully stocked and healthy forests were the exception, when the first attempts at regular management were made, and that the main portion of the so-called forests were groups of trees, separated by vast areas of scrub and grass land. Moreover, the majority of the older trees were unsound, hollow and crippled, the soil was hard and impoverished, and it was clear that protection against fire was the most important task to be accomplished, if real improvement of the forests was to be effected. The attempt, however, to put an end to this time-hallowed institution met with powerful opposition on all sides. Colonel Pearson, the Conservator of Forests in the Central Provinces, was the first to succeed in keeping out fires from the Bori forest in the Satpura hills. This was in 1865, and a few years later the effect of continued protection in that district was marvellous. This and other forests which have thus been really protected, are now dense compact masses of healthy trees and bamboos, which can with advantage be subjected to regular management. The total area of fire-protected forests in the British Indian Empire in 1893 amounted to 27,438 square miles, which is nearly three times the area of State forests in the kingdom of Prussia.

Proprietors of forest lands in Great Britain and in the

United States of North America will do well to bear in mind the success of fire conservancy in India. Systematic forest management is a difficult undertaking, which has many enemies. Nevertheless success is possible, and if these forestry manuals facilitate the attainment of success in this business, their authors will have reason to be well satisfied with their work.

DIETRICH BRANDIS.

THE DEVELOPMENT OF BUTTERFLIES UNDER ARTIFICIAL CONDITIONS.

THE effects which cold and heat, applied to the pupa, produce in the colours and patterns of the imaginal wings, have been studied for many years and by many naturalists. Weismann in 1875 published an account of his own experiments, and those conducted by others, in an essay which was published in this country in 1882 among the "Studies in the Theory of Descent," translated and edited by Meldola.

The experiments described by Weismann have been repeated and greatly extended by Merrifield (*Trans.* Ent. Soc. Lond., 1888, 1889, 1891, 1892, 1893, 1894), while Dixey has published interesting observations on the phylogenetic significance of some of the results obtained (*Ibid.*, 1893, 1894).

While these careful and successful experiments were being conducted in this country, Standfuss of Zurich has been independently engaged on the same research, employing in many cases the very species which had been used by Merrifield. Standfuss's paper, appearing in 1894, has been translated by Dixey, and, after revision by the author, has been published, with an introductory note by Merrifield, in the pages of *The Entomologist* for March, April, and May 1895. The editors of this journal are to be congratulated on the effort they have made to lay before their readers some of the interesting results of entomological research conducted by continental naturalists. We may hope that the attempt which has been so successfully made, will be frequently repeated.

(1) *The Egg.*—The eggs of four species of moth (*Arctia fasciata*, *Dasychira abietis*, *Lasiocampa pruni*, and *L. pini*) were exposed to a high temperature, 34° C. (93° F.), as they were being laid, and subsequently up to the time of hatching. The larvæ hatched in two-thirds or less of the normal time, and although the temperature remained normal, 25° C. (77° F.), throughout the subsequent stages, 71 per cent. of *fasciata*, 90 of *abietis*, 100 of *pruni*, and 81 of *pini* emerged as imagos in that year, the remainder hybernating as larvæ; as against 23, 12, 64, and 28 per cent. respectively, when eggs from the same parents had been laid and kept at a temperature of 22° C. (72° F.) and at 25° C. during the subsequent stages. This persistence throughout the later stages of the hurrying-up of development, when the conditions which originally started it had ceased at the beginning of larval life, is very remarkable, and it is unfortunate that the author should have contented himself with giving his results in percentages instead of the actual numbers obtained. This criticism applies to nearly all the results recorded in the paper.

There was no evidence that the imagos were otherwise influenced by the condition of the ova.

(2) *The Larva.*—Experiments with an increased temperature generally shortened the period of larval development and reduced the size of the imago. From these experiments the author infers that the great difference in size between certain closely allied species (*e.g. Boarmia consortaria* as compared with the much larger *B. roboraria*) has been produced by the larvæ reacting in a different manner under changes of temperature, so that some acquired long and the others short larval periods. It would appear that the evidence in favour of this conclusion has not been sufficiently sifted, and that certain obvious difficulties raised by this interpretation have been overlooked.

Certain changes in form, colour, and marking are also described as following the temperature conditions of the larvæ. In these cases, however, the author does not appear to be giving the results of his own experiments, but reasoning from the differences observed in the several broods of many species appearing at different seasons, and especially contrasting the forms produced from hybernated larvæ with those produced without hybernation. In these cases it is the duty of the naturalist to determine by means of artificial experiments whether the observed changes are entirely due to conditions of temperature, and whether the larval stage alone is of importance.

Many experiments were made with foods, polyphagous larvæ being fed on poisonous or acrid plants, on such abnormal diet as raw meat, or on plants which had absorbed solutions of various substances. The perfect insects "often enough showed a failure in size or general colouring, but in no case any noteworthy variation in tint or pattern."

The effects of light transmitted through glass of different colours were negative, although the larvæ were exposed to these conditions "from the time when they were quite small."

(3) *The Pupa.*—By far the most complete results were obtained by subjecting the pupa to various degrees of temperature.

The effects obtained with *Papilio machaon* and *Vanessa antiopa* are of especial interest, inasmuch as Merrifield's material had been inadequate and his results, as regards these species, negative.

Seventeen pupæ of *P. machaon*, kept at a temperature of 37° C. (98°–99° F.) from the time when the cuticle hardened at the beginning of pupation, produced in seven to ten days fifteen insects, which were much lighter in colour than usual, owing to the development of a yellow powdering which obscured many of the dark markings on the upper and under sides of the wings, and the body. Changes in form are also described, including a marked lengthening of the "tail" of the hind wing. "Some of these specimens . . . bear a perfect resemblance to those that fly in August in the neighbourhood of Antioch and Jerusalem." The pupæ subjected to cold (for twenty-eight days) produced only two imagos, and these resembled the Swiss and German forms emerging from hybernated pupæ.

The pupæ of *Vanessa antiopa*, after being exposed to heat (37° C. or 98°–99° F.) for forty-eight hours, produced, ten days later, butterflies in which the marginal blue appeared to be reduced, and the yellow border broadened, but in neither case to a greater extent than in nature. Among these individuals, however, 2 per cent. presented a very remarkable variation, which Standfuss has named var. *daubi.* This well-marked form is constantly produced when the pupæ were exposed to heat (as above) for sixty hours, and then kept at a temperature of 24° C. (75° F.). Such pupæ produced the var. *daubi* in twelve days. The upper surface of both wings is greatly darkened, becoming almost black, the blue spots are much reduced and have a violet tinge, but the most remarkable change occurs in the yellow border, which is extremely darkened, so as to leave, in extreme cases, only a small remnant of yellow scales. The under side is as much darkened as the upper; and certain changes in the form of the wings are also described.

Cold produced very different effects according to the time of exposure. The most interesting results, and those which most strongly suggest the appearance of allied species (*V. urticæ*, *V. polychloros*), followed the shortest exposure of twenty-nine to thirty-four days in the refrigerator. In these cases the brown ground colour became lighter, and the blue spots (much enlarged on the